

News Briefs

General Developments

Inquiries about News Briefs, where no contact person is identified, should be referred to the Managing Editor, Journal of Research, National Institute of Standards and Technology, Building 820, Room 126, Gaithersburg, MD 20899-0001; telephone: 301/975-3572.

NIST CALIBRATION HEART-ENING FOR NEW TREATMENT

Cardiologists are exploring the use of radiation to prevent coronary arteries from reclosing once opened by balloon angioplasty. In about 30 percent of cases, angioplasty must be repeated due to blood vessel restenosis (reclosing). Research indicates that radiation treatments may prevent scar tissue from forming in arteries that have been stretched during angioplasty. However, delivering the proper dose of radiation to tiny artery walls and avoiding the surrounding tissue is a complex measurement challenge. NIST physicists are helping meet this challenge by calibrating radioactive seeds developed by a private company for surgeons to insert into coronary arteries. NIST's role is to design methods for accurately measuring the seeds' radiation dose. A NIST physicist explains that the small size of the seeds and their tiny treatment area make calibrating them and predicting their behavior in an artery more difficult than assessing conventional medical radiation sources. Using beta particle radiation standards at NIST and specialized radiographic films, the physicist has calibrated a series of seeds for the company. The calibrated seeds will help researchers evaluate the effectiveness of radiation therapy in angioplasty patients.

MAMTC HELPS SMALL BUSINESSES IMPROVE, CUT COSTS

Centers throughout the country affiliated with NIST's Manufacturing Extension Partnership are making a difference in helping smaller U.S. manufacturers

improve their competitiveness through modern technologies and business practices. For example, the Mid-America Manufacturing Technology Center recently helped two small Denver companies improve productivity and reduce costs. MAMTC partnered with a weaving consulting company to provide a 4-week training course on maintaining and repairing projectile weaving machines and on textile technology at a private company. According to the company president, "As a result of this training, ... we have realized an increase in our per shift production during the month of November 1995 of 9.5 %. In December productivity increased another 7.7 %." A MAMTC engineer and a private consultant worked with another company to incorporate computer technology into its trophy and sign engraving business. The company projects a \$20,000 increase in annual sales. MAMTC serves firms throughout Colorado, Kansas, Missouri and Wyoming. For further information on MAMTC, contact Marianne Hudson at (913) 649-4333.

NEW JOSEPHSON VOLTAGE STANDARD PROPOSED

NIST researchers are proposing a new programmable Josephson voltage standard with improved accuracy and speed. The new standard would improve the metrology of voltage standards by allowing higher-frequency alternating current (ac) standards; it would also increase the speed with which other calibrations can be performed, such as analog-to-digital and digital-to-analog converter calibrations. The new standard would use a single series array of Josephson junctions that are driven by a variable frequency pulse train (conventional voltage standards use a sinusoidal drive current). Currently, an array of thousands of Josephson junctions has to be broken up into binary sequences in order to get different voltages. This stepping process limits the accuracy and frequency of ac voltages that can be generated. Driving the array with a variable frequency pulse train dramatically increases the circuit's operating margins over its frequency range from zero to 10 GHz. Experimental

results on a prototype circuit have been encouraging. For a paper describing this development, contact Sarabeth Harris, Div. 104, NIST, Boulder, CO 80303-3328, (303) 497-3237, e-mail: sarabeth@micf.nist.gov.

COMPACT MODEL OF VOLTAGE STANDARD ROLLED OUT

Josephson voltage standards (JVS) and their accompanying calibration systems traditionally have been too bulky to transport, limiting calibration services to only a few laboratories. Scientists at NIST have designed a compact, transportable 10 V Josephson calibration system. Its weight and volume are less than one-third that of current systems, while featuring a relative standard uncertainty of 2×10^{-8} . The new JVS is highly automated and designed to be operated by technicians without higher level support. The first prototype is cooled by liquid helium with a 100 L Dewar sufficient to operate the Josephson array for 6 to 8 weeks. The final version is designed to be cooled with a portable 4 K refrigeration system. The prototype JVS will be shipped shortly to Sandia National Laboratories in Albuquerque, NM, for evaluation against current state-of-the-art laboratory standards. It will then be sent to selected NASA and Department of Energy laboratories for field testing. Paper no. 4-96 describing the portable system is available from Sarabeth Harris, Div. 104, NIST, Boulder, CO 80303-3328, (303) 497-3237, e-mail: sarabeth@micf.nist.gov.

ASSISTANCE JUST A CALL OR CLICK AWAY

Whether it's dialing an easy-to-remember telephone number or clicking a mouse to surf the Internet, small and medium-sized manufacturers looking for assistance in solving real-world technical and business problems now have improved access to NIST's Manufacturing Extension Partnership. Dialing 1-800-MEP-4MFG (800-637-4634) will directly link a smaller manufacturer with the nearest MEP affiliate or to MEP headquarters at NIST's Gaithersburg, MD, facility. The MEP is a nationwide network of locally managed centers in 42 states and Puerto Rico; all rely on experienced field agents who provide hands-on assistance to address manufacturers' most critical needs. Those with access to the World Wide Web also can find information about the MEP and its affiliate centers through a newly revised home page at <http://www.mep.nist.gov>. Called "The MEP Source," it includes a locator map for centers and field offices, links to MEP network expertise and resources, and other points of interest such as listings of manufacturing-related web sites and upcoming trade shows.

"INFRASTRUCTURE" AWARDS FUND IMPROVED CENTER SERVICES

NIST recently announced 16 awards to help build the core capabilities of centers affiliated with the Manufacturing Extension Partnership nationwide and, in turn, improve the services offered to small and medium-sized manufacturers. The awards are for projects in the following three areas:

- Training and tools (10 awards): Courses will be developed to help MEP field engineers diagnose a smaller manufacturer's problems and work with the company to find solutions. Tools will better prepare agents to help smaller firms in areas such as environmental assessment, benchmarking and marketing.
- Workforce and workplace development (five awards): These projects will help MEP centers offer information and assistance in addressing human resources issues and needs.
- Information infrastructure (one award): MEP centers will be provided with tools and techniques making it easier to find, synthesize and present electronic information.

CONSORTIUM AIMS FOR BETTER CHIP MEASUREMENT

Five companies and the computer consortium SEMATECH have joined forces with NIST in a new consortium to develop instrumentation that will support manufacturers' efforts to pack more and more features into tomorrow's semiconductor chips. Corporate members of the new Scanning Capacitance and Electromagnetic Sensor Consortium plan to research new ways to measure accurately the relative location or overlay of features in successive semiconductor chip layers. Successful feature placement requires overlay metrology having an uncertainty less than 10 nm. Consortium members will examine and compare two new methods—scanning capacitance probes and electromagnetic sensors. Consortium project director who is an engineer at NIST said "Enhancements in semiconductor wafer metrology will help secure the United States' leading position in the market for overlay metrology tools, and indirectly help maintain the nation's leadership in the multibillion dollar global semiconductor industry." For technical information, contact Michael Cresswell at B360 Technology Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-2072, e-mail: michael.cresswell@nist.gov.

TURBINE BLADES "CAST" IN STARRING ROLE BY X RAYS

Jet engine manufacturers are concerned about the temperature and stress performance of the super-alloy turbine blades used in their products. One way of obtaining consistently high performance is to monitor the blades as they are being cast to ensure single-crystal growth. NIST has developed an x-ray sensor that may fit this monitoring requirement. The sensor provides an unequivocal location of the boundary between a liquid metal and a solidifying crystal while they are still in a casting mold. High-energy x-rays are used to penetrate the walls of the mold and, by observing the x-ray diffraction pattern, movement of the solid-liquid front may be followed during solidification. Withdrawal of the mold through a precisely controlled temperature gradient in the casting furnace creates the conditions for solidification crucial to the single-crystal casting process; the desired crystal is formed if done slowly enough. Until now, the speed of the withdrawal has been determined by trial and error or by modeling. In a recent report, the NIST researchers said they had "tested the x-ray diffraction sensor on specimens of pure aluminum and copper in a gradient furnace, and found that the solid-liquid boundary could easily be identified even though the specimens were surrounded by a mold wall and encased within a furnace." For a copy of technical paper no. 9-96, contact Sarabeth Harris, Div. 104, NIST, Boulder, CO 80303-3328, (303) 497-3237, e-mail: sarabeth@micf.nist.gov.

"AIRBAG" TECHNOLOGY MAY SOON SNUFF FIRES

The same technology that automobile manufacturers use to inflate airbags soon might save lives and property as a fire suppressant. According to a NIST scientist, solid propellant gas generators—essentially automobile airbag inflators without the bag—have great futures in this role. Recent tests performed at the Naval Air Warfare Center in China Lake, CA, and Wright Laboratory in Dayton, Ohio, have demonstrated the feasibility of using such systems to suppress simulated aircraft dry bay fires. Manufacturers also have suggested the technology's use for warehouse fire protection, industrial explosion prevention, and race car and shipboard engine fire control. A solid gas generator fire suppressant system would be physically very compact and have no ozone depletion and global warming potential. NIST scientists currently are designing a test for evaluating fire suppression efficiencies of gas generators. The researchers plan a simple apparatus that at the same time will reveal other important data such as oxygen concentration, temperature and pressure. For technical information on the experimental fire suppressant,

contact Jiann Yang, B356 Polymer Building, NIST, Gaithersburg, MD 20899-0001, (301) 975-6662, e-mail: jiann.yang@nist.gov.

ENGINE FUELS LAW TO BE CHANGED TO PROTECT CONSUMERS

Officials in the National Conference on Weights and Measures are expected to adopt revisions to the Uniform Engine Fuels, Petroleum Products, and Automotive Lubricants Inspection Law that would make it illegal to misrepresent the "brand" of a product. The changes are aimed to protect consumers from firms who make false claims on fuels. The changes to NIST Handbook 130, Uniform Laws and Regulations, will be voted on by delegates to the 81st Annual Meeting of NCWM, July 21-25, 1996, in New Orleans. The recommended changes are proposed by NCWM's Laws and Regulations Committee with the cooperation of industry. NCWM is a standards-writing organization of more than 3500 state, county, and city weights and measures officials and associated business, federal and consumer representatives. NCWM receives technical support from the NIST Office of Weights and Measures. For information on the 81st Annual Meeting, contact NCWM, P.O. Box 4025, Gaithersburg, MD 20855, (301) 975-4012, fax: (301) 926-0647, e-mail: owm@nist.gov.

ENERGY-RELATED INVENTIONS PROGRAM RECOMMENDATIONS

During February 1996, the NIST Office of Technology Innovation recommended an innovative technology for commercialization to its Department of Energy partner under the Energy-Related Inventions Program.

PowerRim CFL Adaptor for Recessed Downlights—the technology is a retrofit kit for recessed parabolic-shaped downlights so that fluorescent lamps can be used instead of incandescent lamps. An estimated 200 million downlights could be candidates for the retrofit kit since use of the adaptor significantly reduces the amount of electric energy required for the same amount of light output.

NIST TESTING STRATEGIES APPLIED TO CALIBRATION SERVICE REDUCES COST TO CUSTOMER

NIST has applied its testing strategies methodology to the calibration of commercial ac voltage transfer standards, with resultant savings to the customer of as much as \$20,000 per instrument calibrated. The savings result from a reduction in test points, for example, from 309 to 108, while certifying that the customer's instrument satisfies the specified tight uncertainty at all points. This accomplishment is an example of the results of long-term research on testing strategies carried out by NIST.

Efficient testing is an essential ingredient for competitive manufacturing of electronic products. In some cases, the testing cost (including calibration) can approach and even exceed the original manufacturing cost. The NIST effort is providing widely applicable analytical tools that can lead to reduction of testing operations and an improved prediction in the performance of the item under test.

The NIST approach, empirical linear prediction (ELP), relies on the use of a linear model that is based on empirical data obtained from measurements made on representative test items. A NIST scientist has completed work on analyzing the effects of non-model errors and shown how this analysis can be used to estimate the resulting uncertainties in predictions made when using the original model. The scientist first presented this analysis to industry in the paper, "Effects of Nonmodel Errors on Model-based Testing," at the 1995 IEEE Instrumentation and Measurements Technology Conference. Another NIST scientist then applied the new approach to create and evaluate prediction intervals for two widely used commercial ac voltage references. For both instruments, he was able to show that 95 % prediction intervals (based only on measurements taken at the reduced set of test points) actually bounded slightly more than 95 % of the measurements at all points. This work is the first demonstration that the ELP method can be applied effectively and accurately to production-line electronic instruments. As a result, NIST plans to use the ELP method in calibrating the two specific instrument types in the future and will investigate other candidate instrument types.

NIST ESTABLISHES TRACEABILITY LINK WITH ELECTRICAL METROLOGY LABORATORIES IN ECUADOR

NIST continues to support the development of metrology in Ecuador under the terms of an agreement between NIST and the national standards laboratory of Ecuador, the Instituto Ecuatoriano de Normalization (INEN). Recently, three NIST staff members made a four-day visit to INEN and the Army calibration laboratory (CALE), temporarily designated by INEN as the electrical metrology laboratory of Ecuador; both INEN and CALE are in Quito. The visit also entailed invited participation in a National Metrology Seminar held at the Military College of Ecuador in Sangolquí. Another purpose of the trip was to provide CALE with selected electrical measurement capability traceable to NIST. Earlier, as the first technical activity under the agreement, NIST had hosted two Ecuadorian metrologists, each for a year. During their stay, these individuals purchased instrumentation from U.S. manufacturers, which was then calibrated at NIST before being sent to

CALE. By establishing strong links to the metrology infrastructure of countries such as Ecuador, NIST expects to provide a technical basis for future trade agreements.

At the National Metrology Seminar, NIST representations gave an overview of electrical measurements, detailed talks on voltage, current, phase, impedance, power and energy measurements. At CALE, a NIST scientist carried out transfer measurements using a NIST-calibrated digital multimeter hand-carried to Ecuador, with the result that Ecuador now has standards for five electrical quantities directly traceable to NIST. Also at CALE, the scientist delivered and demonstrated a NIST-built digitally synthesized source, purchased by CALE. This activity involved the writing of software routines on the spot to permit CALE staff to convert the control language for the source to one available at CALE. Later, one of the NIST scientists visited a new INEN site with INEN's director and discussed how INEN could establish a watt-hour meter calibration service.

RESULTS OF NIST-LED INTERCOMPARISON OFFER CLUES FOR IMPROVED HIGH-FREQUENCY MEASUREMENTS OF DIELECTRIC AND MAGNETIC PARAMETERS

NIST scientists have completed a laboratory intercomparison involving dielectric and magnetic characterization of bulk materials using the air-filled stripline resonator method. Industry needs improved characterization of the high-frequency electromagnetic properties of materials for a variety of new uses such as the introduction of high-uniformity substrates for printed-wiring boards. The resonator method is used widely in commercial aerospace and government laboratories for accurately characterizing low-to-medium loss dielectric and magnetic materials in the frequency range 50 MHz to 5000 MHz. This is the third laboratory intercomparison that NIST has organized and conducted as part of an assessment of the quality of practical U.S. microwave dielectric and magnetic characterization measurements. Conclusions drawn from the study include: (1) the stripline resonator method and dimensions can be optimized and standardized for permittivity and permeability measurements to achieve relative uncertainties on the order of 10 % and 5 % respectively; (2) asymmetrical loading of the resonator can lead to radiation losses and greater uncertainties in loss-tangent measurements; (3) exceeding the limits of small perturbation theory, for example by using too large a specimen, can lead to greater uncertainties; and (4) inclusion of the demagnetization correction is essential for accurate permeability measurements.

Bulk pieces of two dielectric and three magnetic materials were supplied to six participating laboratories. From these materials, each participant prepared specimens to fit into its measurement fixture, the design of which varied from one laboratory to another. When the analysis was complete, comparison data showed about a 15 % variation among the participating laboratories.

NIST DEVELOPS THREE-AXIS CORRECTION METHOD NEEDED FOR MEASUREMENTS OF SATELLITE STEERED-BEAM ANTENNAS

Responding to needs of the satellite communications community, NIST has developed an algorithm and software to correct for the first time probe-position errors in all three axes, x , y , and z , in measurements of antenna performance by planar near-field scanning. The new capability addresses the increasing use of communication satellite antennas with beams steered to as much as 30° off boresight, the direction in which the antenna is pointing. The far-field antenna pattern with the antenna operating in the intended off-boresight directions has to be verified by planar near-field scanning prior to launch.

From the point of view of the limits imposed by probe-position correction capabilities, this algorithm and its implementing software will permit users of current planar near-field scanners to extend the frequency range of their systems above the present practical limit of about 75 GHz to frequencies above 500 GHz, perhaps as high as 1000 GHz. Application of the algorithm also is expected to make possible the development of less expensive, lighter-weight scanner structures for field testing of antennas, without increased uncertainty.

The algorithm implements an efficient iterative method that requires a number of operations per iteration proportional to $N \log N$, where N is the number of data points. Tests have shown that the algorithm is robust and capable of correcting for x and y positioning errors that are large in comparison to the sample spacing (typically, a half wavelength) and for z positioning errors that are greater than a wavelength.

HIGH SPEED MILLING

With improvements in machine and spindle technology, high-speed milling is becoming an increasingly viable industrial process. In the aerospace industry, manufacturers have machined thin-walled components by using machines with spindle speeds in excess of 30000 rpm. An important issue in high-speed milling is the dynamic interaction between tool and workpiece. A thorough understanding of this challenging issue is yet to be attained. Due to the intermittent nature of the cutting process and other factors, the dynamics of milling is

nonlinear and difficult to model. In most of the related research, the focus is on stability predictions by using retarded dynamical systems, which do not properly account for the intermittent nature of the cutting process. This aspect is taken into account in the current work, where the focus is on the nonlinear impact dynamics inherent in the milling of thin-walled workpieces.

End-milling experiments were conducted by a NIST scientist, in cooperation with the University of Maryland, with a thin-walled, cantilevered, aluminum workpiece on a conventional CNC milling machine using a two-fluted cutter. The workpiece was instrumented with strain gages to measure bending and torsional vibrations. The strain-gage signals collected during upmilling and downmilling were analyzed using the following tools: 1) Fourier spectra, 2) phase-plane plots, 3) Poincaré sections, 4) dimension calculations, and 5) wavelet transforms. A phenomenological model was developed to explain the nonlinear impact dynamics observed in the experiments. The model has been used to explain the qualitative features of the experimental results. Poincaré sections and bifurcation diagrams of the workpiece motion predicted by the model show both periodic and chaotic motions. The experiments and analysis in this work clearly point out the need for considering nonlinear impact dynamics during milling of thin-walled structures. It is expected that this consideration will contribute to gaining a better understanding of workpiece/tool interactions during high-speed milling.

NEW CALIBRATION SERVICE DEVELOPED FOR HIGH PRESSURE GAS

NIST recently completed development of a new calibration system for high gas pressures to meet the needs expressed by industrial and military customers. These customers routinely measure high gas pressures and some of their applications require highly accurate measurements which require state-of-the-art measurement systems, such as precision gas piston gages, for their support. Although NIST has had the capability of providing oil pressure calibrations as high as 280 MPa (41 000 psi) for a number of years, the calibration capability for gases was limited to 16 MPa until now. The oil calibrations rely on NIST's primary standards, which are controlled-clearance oil piston gages. The approach taken to provide high-pressure gas calibrations relied on transferring this primary (oil) standard to secondary gas standards. Two commercially available, high-pressure, gas piston gages were chosen as transfer standards and the comparison to the primary standard achieved by means of a differential pressure cell to isolate the oil-air interface. The two gas gages of considerably different design were determined to be stable transfer standards

for high-pressure gas measurements and to have a relative two-standard deviation uncertainty of 38×10^{-6} ppm from 9 MPa to 110 MPa. A calibration service for helium gas is being implemented based on the two transfer standards; extension to other inert gases is being considered for the future.

PATENT ISSUED ON METAL SILICIDE THERMOCOUPLE

The U.S. patent, "Thin-Film High Temperature Silicide Thermocouples," was issued on Dec. 12, 1995. This patent discloses a technology for producing thin-film thermocouples capable of measuring temperatures up to 1200 °C, which also provide greatly enhanced stability in hot oxidizing atmospheres or highly corrosive aqueous environments. These thermocouples incorporate thin film metal silicides, for example MoSi_2 , TiSi_2 , TaSi_2 , or WSi_2 , with a SiO_2 overlayer and an underlying silicon layer. This configuration provides a very stable composition for the metal silicide leg of the couple and, therefore, a very stable calibration in oxidizing and aqueous corrosive environments. These environments cause unacceptable composition-driven changes in the calibration for most conventional thermocouple materials when in thin-film form. The films can be sputter deposited on high-temperature components of complex shape such as turbine blades. The thin-film thermocouples are capable of very fast response in the microsecond range due to their small size. Thermocouple junctions of volume 10^{-7} mm^3 have been produced, which also enables extremely fine spatial resolution. A cooperative effort for engine applications is under way with a gas-turbine engine manufacturer. Other applications being considered are temperature measurements for metal casting molds, droplet solidification, and diesel engines.

ENTANGLED POLARIZATION STATES PROVIDE HIGH RESOLUTION VERNIER FOR POLARIZATION MODE DISPERSION MEASUREMENT

NIST, in collaboration with the University of Maryland at Baltimore, has been investigating a technique employing entangled photon states to measure propagation delay differences between orthogonal polarization modes. This method produces high accuracy without any integer wavelength ambiguity in the result. A new optical variant of the method makes much higher resolution possible. This type of measurement could help quantify polarization dispersion in long length fibers, which is of great importance to the communications industry.

Entangled states consist of pairs of orthogonally polarized photons propagating co-linearly. A non-

polarizing beamsplitter sends the light to two detectors so that either polarization can be detected at either detector. The entangled state is detected as a coincidence between the two detectors. A coincidence can be thought to occur in one of two ways: either an X polarized photon is detected at detector 1 and a Y polarized photon is detected at detector 2, or vice versa. When the propagation delay between the two polarizations is made equal, these two coincidence types become indistinguishable and an interference results. This interference produces a dip in the coincidence rate as the delays between the two polarization modes are adjusted toward equality. The resolution of the technique is set by how well the center of the dip can be determined. Initial work suggested a limit somewhat below 0.1 fs. A new arrangement of optical delay in the system effectively fills the interference dip with oscillations at optical frequencies. The high-frequency oscillation can be considered to be a vernier scale because the zero of the oscillation is locked to the center of the dip. This new effect will allow the dip center to be determined with at least two orders of magnitude higher resolution than was previously possible.

ANALYSIS OF THE COMPLEX ROTATIONAL SPECTRUM OF N_2O_5 OBTAINED FOR THE FIRST TIME

Dinitrogen pentoxide (N_2O_5) is one of the most important reservoir molecules for reactive nitrogen species in the stratosphere. The concentration of N_2O_5 in the stratosphere reaches a maximum concentration at dawn each day. During the day, photolysis by sunlight breaks the molecules apart. Its concentration is monitored by infrared spectral profile recordings.

Recent work at NIST has led to the first high-resolution spectral observations of N_2O_5 . The work was carried out by using one of NIST's high-sensitivity Fourier transform microwave spectrometers. Prior to the NIST work, no correctly assigned high-resolution spectra had been obtained in either the infrared or microwave spectral regions even though many attempts had been made by numerous laboratories around the world. One of the reasons correct spectral assignments were not available until now was explained by the work at NIST. The rotational spectra clearly shows that the N_2O_5 molecules are undergoing a complex set of internal motions, which severely complicates the spectral analysis.

Once the analysis of the rotational spectrum is complete, it will facilitate the high-resolution analysis of the infrared spectrum which is used in atmospheric monitoring. This will enable scientists to better model the infrared band profiles in the atmospheric spectrum leading to more accurate determination of the atmospheric concentration of N_2O_5 .

MAGNETIC RESONANCE IMAGING WITH LASER-POLARIZED ^3He GAS

Researchers at NIST are developing neutron polarizers based on transmission through polarized ^3He gas. NIST researchers are now contributing to an unanticipated spin-off of this research: magnetic resonance imaging (MRI) using polarized ^3He gas. Conventional MRI uses the small thermal-equilibrium polarization of protons in a strong magnetic field as the signal source, and relies on the abundance of water in biological environments to provide enough protons for high signal to noise. However, in tissues that have low water content, such as lung tissue, proton MRI is difficult. Experiments recently have been performed using "hyperpolarized" samples of ^3He or ^{129}Xe gas, produced by spin-exchange optical pumping, to image human and animal lungs. The possible applications of this approach begin with improved lung imaging but could ultimately include the capability to image any part of the body. Researchers at the University of Pennsylvania have initiated a program in polarized gas MRI. Because of the current program in ^3He -based neutron polarizers, NIST researchers have been able to immediately contribute to this work. In addition to technical advice on the apparatus being constructed, these NIST researchers have provided an unpolarized high pressure cell filled with ^3He and oxygen that is being used to calibrate and characterize the MRI apparatus for ^3He measurements. Two methods for polarizing ^3He gas currently are being pursued at NIST for application to neutron polarizers: spin-exchange and metastability-exchange optical pumping. The level of polarization required for polarized gas MRI is actually much lower than that required for neutron polarizers. NIST researchers will assist with the construction of the specialized cells needed for the spin-exchange method, and are considering use of the metastable method for polarizing ^3He gas for MRI applications.

REFERENCE RADIOGRAPHS FOR ALUMINUM WELDS

The latest issue of ASTM Book of Standards Volume 3.03 includes Standard E 1648-95, "Standard Reference Radiographs for Examination of Aluminum Fusion Welds." The Materials Reliability Division worked with a small business, Industrial Quality Incorporated, to develop the set of reference radiographs, which form a companion to this standard. This set of reference radiographs has also completed its review within ASTM Committee E07 on Nondestructive Testing and is available for sale from ASTM. Together, the standard and the reference radiographs provide a standard framework by which aluminum weld quality can be controlled.

The set includes five-step gradations in severity for common discontinuities (fine scattered pores, coarse scattered pores, and aligned porosity), and illustrations of other types (clustered pores, incomplete penetration, tungsten inclusions, undercut, cracks, and crater cracks). The welds were produced on aluminum alloy 6061 and 5083 plates, using welding electrodes of alloys 5356 and 4043. The set of radiographs includes a combination of welds on plate thickness of 3.2 mm and 12.7 mm, to cover welds in various aluminum alloys in thickness up to 19 mm. The radiograph densities range between 2.00 and 2.25 in the weld bead region.

RELATIONSHIP BETWEEN MECHANICAL AND MAGNETIC PROPERTIES OF SHEET STEEL

Because mechanical tests are costly and time consuming, a nondestructive measurement method that could quickly determine mechanical properties would be of great value in the production and use of steel. It is well known that the mechanical properties are related to magnetic properties, which can be rapidly measured, without the necessity of removing material and carefully preparing test samples. However, this relationship must be empirically established for each type of steel. In a cooperative program with the American Iron and Steel Institute, NIST researchers have determined the mechanical and magnetic properties of two series of sheet steel. The series were of two grades, high strength low alloy (HSLA) and ultra low carbon (ULC), and were produced under a wide variety of processing conditions. The results showed that a single magnetic property, such as the coercive field, is not well correlated to mechanical properties for such a wide variety of processing conditions. However, when several (up to four) magnetic properties were determined, models could be constructed that were good predictors of mechanical properties. For example, the yield stress, a critical mechanical property for many applications, could be determined to within ± 8 MPa (± 1.2 ksi) for both grades of steel. These results should be adaptable to portable instrumentation for use in the laboratory, steel mill, or production line.

NEUTRON CRYSTALLOGRAPHY OF COLOSSAL MAGNETORESISTORS

Colossal magnetoresistors (CMR) exhibit a very large change in electrical resistance in the presence of magnetic fields. In principle, this phenomenon can be used to design a new generation of devices for reading magnetic media. This has sparked a world-wide industrial quest to understand the prerequisites for CMR and to find new materials. CMR is known to occur in

$\text{La}_{1-x}\text{M}_x\text{MnO}_3$ perovskites, but recently it was also demonstrated in $\text{Ti}_2\text{Mn}_2\text{O}_7$, which has the pyrochlore structure. Oxygen vacancies are known to be essential for CMR in the perovskite materials, so scientists at a private company have been collaborating with NIST scientists to see if neutron diffraction could be used to determine the level of oxygen vacancies in $\text{Ti}_2\text{Mn}_2\text{O}_7$. They could only supply 0.18 g (0.0003 moles) of sample, because the material is prepared at very high pressure. This amount of sample is one-fiftieth of what is commonly used for powder neutron diffraction but was sufficient for the crystal structure to be determined, using data from the recently developed 32-detector high-resolution powder diffractometer at the NIST reactor. The results proved that CMR exists in the material without any significant amounts of oxygen vacancies, which indicates that a different mechanism for CMR occurs in this material. A paper describing this work has important potential consequences since it suggests that many more materials may exhibit CMR than was previously thought.

NIST COLLABORATES WITH INSURANCE COMPANY TO INVESTIGATE NEW RESIDENTIAL FIRE SUPPRESSION TECHNOLOGIES

Responding to a request from an insurance company, NIST scientists provided technical support for and participated in a series of fire suppression experiments conducted in Champaign, IL on Dec. 18, 1995. The experiments were performed to investigate the effectiveness of new residential fire suppression technologies that utilize less water than current residential fire suppression systems. Fire suppression systems with low water flow requirements are needed in areas with limited water supplies. Three types of residential fire suppression systems were tested: a residential sprinkler system designed in accordance with the National Fire Protection Association's 13D, Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwelling and Manufactured Homes; a prototype water mist system; and a prototype self-contained system utilizing an aqueous based chemical fire suppressant. In addition to examining the fire suppression effectiveness of each system, the insurance company is also examining the installation, maintenance, and post-fire, clean-up costs associated with each system. These tests demonstrated the life safety potential of using low water flow fire suppression systems in homes.

NIST STEP VALIDATION PROCEDURES ISSUED

NISTIR 5771, Standard for the Exchange of Product model data (STEP): Procedures for NIST STEP Validation, establishes operating procedures for administering NIST's validation program for proposed Federal Information Processing Standard (FIPS), Standard for the Exchange of Product Model Data (STEP). The document addresses the policy and requirements for NIST certification of STEP implementations. The testing information available from NIST will aid industry as well as federal procurement authorities to determine if the STEP implementations offered to the government comply with federal requirements.

NIST PUBLISHES VERSION 3.0 OF THE APPLICATION PORTABILITY PROFILE

NIST Special Publication 500-230, Application Portability Profile (APP) The U.S. Government's Open System Environment Profile Version 3.0, integrates industry, Federal, national, international, and other specifications into a Federal application profile to provide the functionality necessary to accommodate a broad range of federal information technology requirements in an Open System Environment (OSE). The report provides recommendations on a variety of specifications that agencies can select to meet their requirements for open systems. Version 3.0, which includes many new specifications and updates recommendations made in prior versions, supersedes NIST Special Publication 500-210 (Version 2.0).

NEW PUBLICATION PRESENTS OPEN SYSTEM ENVIRONMENT ARCHITECTURAL FRAMEWORK

NIST Special Publication 500-232, Open System Environment (OSE): Architectural Framework for Information Infrastructure, identifies a set of interfaces, services, and formats to be provided to users of an information infrastructure and the methods for accessing these services. These interfaces, services, and formats describe an Open System Environment, enabling the existing and emerging information infrastructure for the communications, computing, and entertainment arenas to seamlessly interoperate. The document, which was developed under sponsorship of several federal agencies, provides technical guidance about the use of the information infrastructure for exchange of government information and services within government, and to deliver government information and services to citizens and organizations outside of government.

WORLD'S MOST ACCURATE ELECTRON COUNTER DEBUTS

NIST scientists have been working for several years to develop a fundamentally new type of capacitance standard based on measuring the voltage produced when a known charge is placed on a capacitor. The key component of this standard is an electron pump, which transfers electrons one by one onto a capacitor. Consisting of a chain of micrometer-sized metal islands connected by sub-micrometer tunnel junctions, and operated at a temperature near absolute zero, the electron pump relies on an effect known as the Coulomb blockade to control the motion of individual electrons. Because the island capacitances are small, the charge of a single excess electron is sufficient to prevent other electrons from tunneling onto a given island. Due to this blockade effect, a sequence of voltage pulses applied to successive islands through gate capacitors can be used to advance a single electron from one end of the pump to the other. Recently, scientists demonstrated a pump with six islands and seven junctions that has a counting relative standard uncertainty of 15×10^{-9} . This uncertainty will allow about 70 million electrons to be placed on a capacitor with an uncertainty of just one electron. In addition, when biased in the hold mode, the seven-junction pump permits an electron to leak on or off the capacitor only once in about 10 min, allowing sufficient time for an accurate voltage measurement. For a copy of paper no. 5-96 that describes the technology, contact Sarabeth Harris, Div. 104, NIST, Boulder, CO 80303-3328, (303) 497-3237, e-mail: sarabeth@micf.nist.gov.

SEMINAR ON STANDARDS INFORMATION

NIST and the Department of Commerce co-sponsored a seminar on standards information April 22-26, 1996, for representatives from Russia, Romania, Lithuania, and Ukraine. The seminar was aimed at assisting these countries in developing an infrastructure preparatory to their access to membership in the World Trade Organization (WTO). Seminar topics included establishment and obligations of an inquiry point under the WTO Agreement on Technical Barriers to Trade, setting up a national standards information center, sources of information, computerized databases, and indexing tools.

The National Center for Standards and Certification Information at NIST, which also serves as the U.S. inquiry point under the North American Free Trade Agreement, contains an extensive reference collection of standards and standards-related information. NIST staff annually respond to approximately 9000 requests concerning U.S., foreign, and international standards, technical regulations, and conformity assessment procedures.

NTEP CERTIFICATE OF CONFORMANCE ISSUED FOR AN AUTOMATIC WEIGHING SYSTEM

The National Type Evaluation Program (NTEP) has issued the first Certificate of Conformance for a check-weigher, a type of automatic weighing system used in high-speed food processing plants. NTEP, which is jointly sponsored by NIST and the National Conference on Weights and Measures (NCWM) and is administered by staff in the NIST Weights and Measures Program, evaluates models of commercial weighing and measuring devices to determine their conformance to the requirements in NIST Handbook 44, Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices. In July 1995, the NCWM approved a tentative code containing requirements for automatic weighing systems for inclusion in the 1996 edition of Handbook 44. The code, although tentative for purposes of enforcement by weights and measures officials, became effective immediately for type evaluation purposes. The U.S. Department of Agriculture, which regulates a number of plants where automatic weighing systems are used, first approached the NCWM several years ago and requested help in developing requirements and tests for use in evaluating these devices. The NCWM responded by developing the tentative code and an NTEP checklist for automatic weighing systems published in NCWM Publication 14, NTEP Administrative Procedures, Technical Policy, Checklists, and Test Procedures.

ENERGY-RELATED INVENTIONS PROGRAM RECOMMENDATIONS

During the month of March 1996, NIST recommended four innovative technologies for commercialization to its Department of Energy partner under the Energy-Related Inventions Program.

- Reciprocating Rod Pump Seal Assembly—a dual-seal stuffing box used on the surface in oil and gas wells designed to contain corrosive fluids.
- PowerCore: Combined Battery and Structure for Heightened Energy Storage in Electric Vehicles—a battery system for an electric vehicle, which makes use of the considerable volume that is contained within the vehicle's frame.
- RR-1 Insulating Screw Cap—a patented mechanical fastener for attaching rigid thermal insulation board and single-ply roofing membrane to flat and low-slope metal roofs used in commercial and industrial buildings.

- A Process for Drying Low-Rank Coals and Stabilizing the Dried Coal to Prevent Spontaneous Combustion—a process and hardware for drying western lignites and other low-rank coals that have high moisture content (mass fraction of 30 %) and for stabilizing the dried coals so they do not self ignite, (currently the main impediment to using lignites and other low-ranked coals).

NIST DEMONSTRATES BREAKTHROUGH X-RAY MICROCALORIMETER

NIST scientists have demonstrated an x-ray microcalorimeter with an energy resolution of 13 eV, as verified by a measurement of the x-ray fluorescence spectrum of titanium. This resolution is a factor of 10 better than state-of-the-art silicon detectors. The microcalorimeter system is made possible by three major technical innovations. First, the microcalorimeter, which consists of a normal-metal absorber deposited on a free-standing silicon nitride membrane, uses a superconducting transition-edge thermometer consisting of an aluminum-gold bilayer. The bilayer technology was developed to provide a sharp superconducting transition at a controllable temperature near 100 mK, where microcalorimeter operation is optimal. Second, the thermometer is operated using electrothermal feedback to improve detector linearity and speed. Derivation of the stability conditions for electrothermal feedback has maximized the utility of this technique. Third, an adiabatic demagnetization refrigerator was developed to provide the required 100 mK operating temperature with the same convenience as 4.2 K is normally achieved.

In addition to these innovations, the microcalorimeter uses a series-array SQUID preamplifier previously developed at NIST for low-noise wide-bandwidth applications. Although the resulting system combines several ideas at the cutting edge of technology, initial tests suggest that further development will lead to a fully practical instrument that has the potential to revolutionize x-ray surface analysis. A paper describing the microcalorimeter has been submitted to *Applied Physics Letters*.

NIST RESEARCHER INVENTS METHOD FOR FABRICATING THIN-FILM NARROW-LINE STENCILS

A NIST scientist has devised an easy-to-implement method for making self-supported thin metal stencils, that is, continuous sheets having defined sets of openings. Stencils of this type are potentially useful for masks for thin-film processing, such as ion milling and

implantation, that can be enhanced by the use of a stencil mask. Other likely applications of the stencils include fabrication of micro-electromechanical machines and the development of innovative materials. A potential use of particular interest to NIST researchers is as focusing standards for various types of advanced microscopes.

The scientist's stencils consist of thin films of aluminum, with precisely defined holes and trenches; they can be captured from solution onto both solid and perforated substrates, such as glass slides, silicon wafers, and the copper grids used in transmission electron microscopy. The fabrication sequence uses the overlayer film left over from lift-off patterning. While similar stencils have been fabricated before using other techniques, the new method offers several advantages. The most important is that the method requires only the capability to perform standard lithography and thin-film deposition, without capabilities for dry etching or other sophisticated processing. In addition, by using the negative of the lithographically defined pattern, a small number of trenches of lateral size down to 100 nm in an otherwise continuous stencil can be produced using electron-beam lithography with very little beam-rastering necessary so that the exposure times are small. By using multiple-angle metal deposition, the scientist has fabricated trenches substantially narrower than the lithographic opening. He believes his method will permit those who have access to photolithography, but not to electron-beam lithography, can make nanometer-scale stencils, i.e., stencils having openings significantly smaller than the lithography resolution limit. He has found that while stencils having a thickness of about 30 nm are fragile, stencils having a thickness 100 nm and greater are quite robust: the stencils are readily handled without breaking (for example with tweezers) and without any special precautions or equipment. Because of the specific capabilities of his equipment, the scientist has not produced stencils thicker than 400 nm.

REPORT PRESENTS DETAILED SEMICONDUCTOR OPTICAL CHARACTERIZATION SURVEY RESULTS

The detailed results of a survey of 42 firms conducted by NIST on industrial practice in the semiconductor industry with respect to optical characterization methods have been reported in NIST Special Publication 400-98. The publication, *Semiconductor Measurement Technology: Survey of Optical Characterization Methods for Materials, Processing, and Manufacturing in the Semiconductor Industry*, responds to a strong industry interest in obtaining the information and

expands on material presented in Semiconductor Characterization: Present Status and Future Needs, the proceedings of the 1995 international workshop on the same topic.

A significant finding of the study is the need expressed by many industrial users for improved standards and test methods for optical characterization, especially in the area of film thickness and composition; lack of technical support is the main reason given for not employing optical methods. As might be expected, the nondestructive nature of optical methods is a major reason for both their present use and for their future importance for in-situ characterization. A number of respondents indicated they felt a need for workshops on optical methods.

FOOTWEAR INDUSTRY ESTABLISHES STANDARDS COMMITTEE AS A RESULT OF NIST'S EFFORTS

The committee established to develop interoperability standards for the footwear industry held its first meeting on March 29, 1996, in Columbia, MD. The committee was organized by the Footwear Industries of America (FIA), and the meeting site chosen was the headquarters for both the Pedorthic Footwear Association and the National Shoe Retailers Association. Meeting participants included a diverse cross section of leaders from the mainstream and special-needs footwear industries and related medical, scientific, and technological communities. The committee traces its origin to the effort initiated in the NIST custom therapeutic footwear project begun in 1994. The March 29 meeting was a significant milestone in the transfer of NIST's work to date to industry stewardship. Specifically, NIST presented a context for interoperability standards for the footwear industry, and specific foot-measurement entities were proposed by NIST and industry for a standard. The committee established a mission statement to continue its activities to develop standards for the footwear industry, and an organizational structure for the committee was discussed. FIA will lead the effort until an industry representative is selected to chair the committee.

ACOUSTIC FIELD TRANSDUCERS

Increased understanding of the acoustic field of focused transducers will make them more useful in material characterization applications. Whereas the radiated acoustic field of transducers with flat, uniform surfaces is fairly well understood, the acoustic field of focused transducers is not. Having a transfer function for the transducer response would be useful in interpreting the

transducer output when using the transducer for material characterization and defect identification. The diffraction correction factor for a transducer first acting as a transmitter and then receiving the signal reflected from a rigid plane is useful in determining the system transfer function of a pulse-echo system. NIST scientists are developing computer software for calculating the diffraction factor of focused transducers. The diffraction factor can be calculated for continuous waves reflecting from rigid planes near the focal plane. Work is continuing to extend that capability for pulsed waves, non-rigid reflectors, and reflectors, not near the focal plane.

PHOTOMASK LINEWIDTH STANDARDS

National Physical Laboratory, which is the national metrology institute of the U.K., and NIST have completed comparative measurements on two national photomask linewidth standards. The purpose of the comparison was to detect any systematic differences or trends in their linewidth calibration systems and to assess the reasonableness of their uncertainty statements. Both laboratories measured linewidth, spacewidth, and pitch features on both national linewidth standards (175 features total), covering the range of 0.5 μm to 70 μm .

All of the measurement differences were well within the calibration uncertainties of both laboratories. The mean differences were less than 7 nm for all three feature types, the worst case being 42 nm. Regression analysis of the pitch data implies a scale factor difference of 75 between the two countries in this 100 μm range. Similar comparative measurements are planned with other countries that have linewidth standards.

NIST RESEARCH AIDS FBI AND FORENSIC LABORATORIES

Over the past three years, NIST's interactions with the FBI's human identification program have led to a number of fruitful collaborative tests. One of the significant impacts of NIST examinations of FBI data has been the graphical analysis and presentation of interlaboratory data. Components of NIST's SRM 2390, DNA Profiling Standard, have been examined extensively and subsequently have had their certified values become part of a national quality assurance program for the FBI's Combined DNA Information System (CODIS). A NIST scientist developed a statistical analysis and charting routine in the form of a set of spreadsheet macros for use with the FBI's database system. This software, in combination with a CODIS database interface developed by the FBI, allows forensic DNA

laboratories to examine and monitor more easily their RFLP sizing data. Most of the quality assurance data is from sizings of DNA derived from a cell line, K562, one of the components of the NIST SRM.

On March 1, 1996, a beta test of the macros was sent by the FBI to at least 10 forensic laboratories. These laboratories will be able to have the proper data extracted from their databases, plot their own laboratory's results against the NIST-defined boundaries, plot a data dependent boundary in the form of an ellipse, and plot a percent-about-mean window centered on the NIST K562 certified values. Other windows may be plotted about the data being analyzed and users may configure several parameters for data plotting.

Ultimate integration of the NIST graphing routines into the national DNA identification system is planned after feedback is obtained from participating laboratories. These data analysis routines will aid forensic laboratories in maintaining a high degree of quality assurance and quality control.

DETECTION AND CHARACTERIZATION OF INDIVIDUAL NUCLEIC ACID POLYMERS USING A NANOSCALE PORE

DNA, which encodes genetic information, is unique to every individual. Thus, it serves as a marker for personal identification and inherited diseases. Improving the ease and efficiency of selecting, separating, and identifying the sequence of DNA segments is of great interest for both forensic, diagnostic, and therapeutic applications. Rapidly purifying and separating short lengths and small quantities of DNA are two particularly difficult challenges. Researchers at NIST, in collaboration with scientists at Harvard and UC Santa Cruz, recently have shown that an ion channel, a protein that forms a nanoscale pore in cell membranes, can be used to detect and characterize relatively small single RNA and DNA polymers. The method could be extended to separate and sequence polynucleotides.

Individual strands of single stranded RNA and DNA are driven through the pore by an electric field. The presence of polymer in the pore is signaled by a drop in the ionic current, which otherwise flows freely. The duration of RNA-induced transient current blockades is proportional to the polymer length and inversely proportional to the applied potential, which suggests that the polynucleotides electrodiffuse through the pore as linear, extended chains. Experiments using polymerase chain reaction confirmed that the polymers are transported through the pore. The concentration of polymers in solution and the energy required to transport them through the channel is determined from the number of current blockades that occur per unit time.

Currently, this technique can be used to determine the length and concentration of single stranded RNA and DNA. It might form the basis of an ultrafiltration method to separate and purify polymers. With suitable technological advances, this method also could be extended to rapidly sequence polynucleotides if different nucleotide types cause unique degrees of current blockades. Finally, the results furnish estimates for the energy required to transport these biopolymers through narrow portals and, therefore, provide constraints for models of viral infection and some methods of genetic therapies. A patent disclosure on this new technology has been filed.

DATABASE ON THE THERMODYNAMICS OF ENZYME-CATALYZED REACTIONS

Two scientists at NIST have completed a database on the thermodynamics of enzyme-catalyzed reactions. The database contains the results of equilibrium and calorimetric measurements for all six classes of enzymes classified by the Nomenclature Committee of the International Union of Biochemistry. These data can be used for the design and optimization of bioreactors, to calculate equilibrium constants and enthalpies for many reactions that have not been the subject of direct study, to predict the feasibility of reactions before costly research on the design of a catalyst is undertaken, and to understand how biochemical reactions and pathways work (metabolic engineering). The biochemical reactants in the database are cross referenced both with their Chemical Abstract Service registry numbers and with the Enzyme Commission numbers of the enzymes that were used to catalyze the reactions in which the substances participate. The database, which references 870 original articles, has been published as a series of reviews in the *Journal of Physical and Chemical Reference Data*. Work is currently under way to make the database accessible on the World Wide Web.

CAVITY RING-DOWN SPECTROSCOPY OF LOW CONCENTRATION GASES

Researchers at NIST are improving the accuracy and sensitivity of cavity ring-down spectroscopy (CRDS) so the technique can be used to make absolute quantitative measurements in very low concentration gases. Many industrial processes can be impacted adversely by extremely small quantities of common gas phase species (e.g., H₂O, O₂, CO, H₂), requiring standards-grade measurements of species-specific partial pressures at low concentrations. Gas phase absorption spectroscopy can in principle provide species-specific absolute information upon which primary standards of gas concentration could be based. Greatly enhanced sensitivity can be

achieved using CRDS in which gas phase absorption losses are determined by measuring the effective lifetime of light trapped within a resonant optical cavity. Among the numerous advantages of CRDS vis á vis traditional absorption techniques are its insensitivity to fluctuations in laser intensity and atmospheric absorption as well as its ease of implementation. This work is addressing two fundamental problems in making CRDS quantitative: understanding the effects of the bandwidth of the laser source and the line widths of the gas on the decay time and characterizing the mode structure and lifetimes of the empty optical cavity.

To investigate the band/line width effects, rotational transitions of the weak but well-characterized “A” band of O₂ in the range 0.13 KPa to 13 KPa were probed using a pulsed, single-longitudinal-mode Ti-Al₂O₃ laser. The results demonstrate that by properly taking into account the laser bandwidth, absorptivities accurate to better than 3 % can be determined, representing a fivefold improvement in uncorrected results. Using state-of-the-art mirrors with losses as low as 10⁻⁶ ppm/pass, these experiments will be extended to yet lower densities. A theoretical model of the frequency and time-domain response of the CRDS signals in the empty optical cavity has been developed based on stable resonator theory. Experiments support this theory, which predicts that even under pulsed excitation, the optical radiation within a ring-down cavity is dominated by the cavity resonances, a subject of some controversy in the current literature. As a consequence, the complicated time and spatial dependence of real ring-down signals observed in the laboratory can be understood in terms of mode beating effects. It is believed that application of the resonator theory will aid in reaching the ultimate detection limits that CRDS affords, i.e., absorption coefficients as low as 10⁻¹⁰ cm⁻¹.

CHEMICAL DATABASE AVAILABLE ON WORLD WIDE WEB

NIST has developed an interactive database for chemical kinetic mechanisms called CKMech. The chemical kinetic mechanisms consist of both thermochemical data for a set of chemical species and rate constants for a set of microscopic chemical reactions. The database is accessible through the World Wide Web at “<http://fluid.nist.gov/ckmech.html>.” CKMech was developed to make available physical, thermochemical, kinetic, mechanism, and bibliographic data for fluorinated hydrocarbons. This body of information was the basis for the recently published Thermochemical and Chemical Kinetic Data for Fluorinated Hydrocarbons, NIST TN 1412. Provision of the information on a specially designed interactive web page will enhance greatly the availability and utility of the data. In addition

to fluorinated hydrocarbon data, CKMech makes available data for many other species and reactions contained in the JANAF, CHEMKIN, and other thermochemical and kinetic databases available in the public domain. However, these latter data have not been checked for accuracy and the user is encouraged to refer to the original sources for verification.

The database uses three major classifications of information: species data, reaction data, and chemical mechanisms. CKMech Species Data can be searched by chemical name, formula, or compound class. It provides thermochemical functions, NASA polynomial fits, molecular geometries, moments of inertia, vibrational frequencies, and molecular transport properties. It also provides Gaussian ab initio solutions (geometries and energies) where available. Each entry has a “hyperlink” to the relevant citation. CKMech reaction data can be searched by reactants and/or products and provides rate coefficients for specified reactions. CKMech mechanisms allows downloading of chemical kinetic mechanisms in CHEMKIN format. CKMech citations can be searched by author, journal, keyword(s), and year(s).

NEXT-GENERATION NEUTRON FOCUSING LENS CHARACTERIZED

A prototype of a third-generation (monolithic) neutron focusing lens has been characterized recently by researchers from NIST and a private company. This lens will improve greatly both lateral spatial resolution and elemental detection limits for neutron probe techniques. A focal spot diameter of 160 μm (full width at half-maximum) was achieved with this newly designed lens. The gain in current density was determined to be greater than 70 compared to the intensity measured over the same area without the benefit of the lens. The success of this lens can be attributed to a more compact design leading to a neutron transmission of significantly higher efficiency.

Last year this research team produced and characterized a neutron focusing lens that was constructed by forming a precisely oriented array of 1700 polycapillary fibers; each fiber is typically about 0.5 mm in diameter and contains over 1600 hollow channels of about 10 μm diameter. These channels remain uniform and parallel to each other along the entire length of the fiber. The fractional open area of the individual fibers is about 0.5, and the fractional area of the lens (ratio of the area occupied by fibers to that of the entire lens entrance) is 0.175. Consequently, only a small fraction of the neutrons incident on the lens entrance area transmitted and projected to the focus. Nevertheless, the collection area of (50×45) mm² yields a current density gain of about 80 over the focal area of 0.2 mm².

The newly designed lens is much smaller than the previous one; the overall collection area has been reduced by more than a factor of 150 by bundling many polycapillary fibers without space between them. However, the gain in neutron current density is nearly the same. In addition, the focal area of the new lens has been reduced by an order of magnitude. The monolithic assembly starts as a set of parallel channels and is precisely formed at the far end to a focusing taper. The lens was characterized using a white beam of cold neutrons (wavelengths longer than $0.4 \mu\text{m}$) with a current density of $108 \text{ cm}^{-2}\text{s}^{-1}$. Using a specially designed high-resolution detector, the neutron focusing action of this 46 mm long lens was demonstrated. The 0.02 mm^2 (FWHM) focus was determined to be 21 mm from the exit, with a current density gain of 74.

In the future, such monolithic lenses will be used to upgrade neutron beam instruments such as the NIST cold neutron depth-profiling facility, where there is insufficient space for the larger lens. This new generation of neutron lenses will improve both the detection limits and resolution of neutron probe techniques and enable better characterization of technologically important samples.

WEB OFFERING USED AS CURRICULAR RESOURCE

A NIST laboratory's World Wide Web version of the booklet *A Walk Through Time* has been selected as a resource to support the K-8 curriculum. Macmillan/McGraw-Hill School Division, an educational publisher, is launching a Web site that includes teaching suggestions, activities, and lesson plans related to K-8 curriculum. The publisher believes *A Walk Through Time* provides information that might be used by teachers to enhance their curriculum and have included it as a link at their site.

A Walk Through Time provides information on the evolution of time measurement from ancient to modern times covering methods ranging from the apparent motion of celestial bodies to the characteristic frequencies of atoms. It is divided into sections on Ancient Calendars, the Earliest Clocks, a Revolution in Time-keeping, the "Atomic" Age of Time Standards, the World's Time Zones, and NIST Time and Frequency Services plus a bibliography. Both text and graphics are provided in the web version. This document may be accessed over the web via the URL "<http://physics.nist.gov/GenInt/Time/time.html>." Much additional information and many databases may be accessed from the PL home page via the URL "[http:// physics.nist.gov/](http://physics.nist.gov/)."

REFLECTION IN MAGNETIC MULTILAYERS

In magnetic multilayers, electrons in one material can reflect from interfaces between the two materials. This reflection contributes to two effects of significant recent interest: oscillatory exchange coupling and giant magnetoresistance. Exchange coupling between the magnetizations of magnetic layers is the coupling that is mediated by the electrons in a non-magnetic spacer layer that separates them. For some systems it oscillates in sign as a function of the spacer layer thickness and for particular thicknesses gives antiparallel alignment of the magnetizations in neighboring magnetic layers when there is no applied field. The giant magnetoresistance is the change in resistance when the relative orientation of the magnetizations is switched by applying a magnetic field. Devices based on the giant magnetoresistance effect have been proposed as magnetic field sensors and read heads in magnetic disk storage.

To better understand such systems, reflection probabilities for a series of noble metal spacer layers and lattice-matched ferromagnetic layers have been calculated from first principles at NIST. These calculations show strong spin dependence for all systems considered. The calculated reflection probabilities lead to predictions of the coupling strength that will be measured in these systems as the quality of growth continues to improve. The predictions are much larger than measured values, but the measured strengths continue to increase as better experiments are done. These results also suggest that the contribution to the giant magnetoresistance from a process called channeling can be quite substantial. These results are to appear in the *Journal of Applied Physics*.

NEW SPECTROSCOPIC REFERENCE DATA COMPILATION

A new spectroscopic data volume of critically evaluated atomic transition probabilities for all ions and the neutral atoms of carbon, nitrogen and oxygen has been published by two NIST scientists. This 532-page reference data book greatly enlarges, improves, and updates a 1966 critical NBS table for these elements. The number of spectral lines covered in the new edition has increased by almost a factor of 10 to about 12500 spectral lines and the uncertainties are typically reduced by factors of 3 to 10. The most complex spectra are those of the neutral C, N, and O atoms and their singly charged ions, covered with roughly 1000 lines in each case. The typical uncertainties for multiplet data are about 10 %, but for individual spectral lines, uncertainties up to 25 % are encountered. For the less complex

higher ions, the accuracy levels are significantly better, with typical uncertainties close to $\pm 3\%$. The tables are set up individually for each spectrum and are in the format of multiplet tables, containing the latest wavelength and energy-level data and pertinent spectroscopic configurations in addition to the transition probabilities. Allowed (electric dipole) and forbidden (magnetic dipole, electric quadrupole and some magnetic quadrupole) transitions are tabulated separately. Short introductions to each spectrum, sometimes accompanied by graphical data comparisons, contain the most important background information on the data selections.

Spectral data for these common elements are of great interest to several user communities, especially for applications in gaseous discharges, in materials processing, for gas laser development, lighting research, high-temperature plasmas, spectrochemical applications, atmospheric physics, and astrophysics.

FIELD RETARDATION OBSERVED IN MOLECULES

Electromagnetic fields generated at some point in space are not felt instantly at other distant points but propagate at the speed of light. The effect of this delay or retardation is usually too small to be important when the distances are on the atomic scale. Recently, a team of experimental physicists and theoretical chemists from NIST saw the retardation effect in an unusual diatomic molecule. This molecule, an excited state of Na_2 , is a giant. The atoms are nearly 4 nm apart, more than 10 times further than in typical diatomic molecules. This large separation made the retardation effect relatively easy to observe. While the influence of retardation had been known theoretically for many years, until now it had never been observed to affect the interaction between two atoms or to alter molecular binding energies. The effect shows up in the giant molecules because the atoms are so far apart and because both experimental measurements and theoretical calculations are extremely accurate. Having understood the effect of retardation, the research team is now using these molecules for precision measurements of atomic properties.

IR CALIBRATION OF HUBBLE SPACE TELESCOPE INSTRUMENT

Scientists at NIST have developed a low-level spectral radiance capability in the near infrared (800 nm to 2500 nm). This capability was developed to assist in the final ground-based calibration of the NASA's mission, Near Infrared Camera and Multi-Object Spectrograph (NICMOS). NICMOS is a second-generation orbital replace-

ment instrument to be installed in the Hubble Space Telescope in February 1997. Once aboard the Hubble, this instrument will allow observations in the near infrared wavelength regions that are generally opaque to ground-based observatories due to water vapor in the atmosphere. NIST scientists have calibrated a transfer integrating sphere source, which will be used at a private company for final ground testing on NICMOS this June. This source has maximum spectral radiance many orders of magnitude below the NIST scales for spectral radiance.

CALIBRATION SOURCE WILL PROVIDE ON-BOARD RELIABILITY OF COLLECTED OCEAN DATA

NIST, in support of NASA's Sea-Viewing Wide Field-of-View Sensor (SeaWiFS) Project, a study of ocean irradiance, has developed a prototype large-area field calibration light source, the SeaWiFS Quality Monitor (SQM). The SQM, designed to be rugged and economical for field use, will monitor the changes in the sensitivity of marine radiometers during a long cruise. Until now, besides pre-cruise and post-cruise laboratory calibration, on-board measurement capability has not been obtainable to assess the known instability of marine radiometers. These radiometers are operated for weeks in drastic environmental conditions at sea. The SQM will be used to assure the reliability of the collected ocean data to meet the stringent requirements of the SeaWiFS project.

This prototype SQM was used during the month of April for the Atlantic Meridional Transect cruise (AMT) in collaboration with NASA and a private marine laboratory. The AMT began at the Falkland Islands and ended in England. After the cruise, the SQM was assessed by NIST and will be used during the 5th SeaWiFS Intercalibration Round Robin Experiment (SIRREX-5) at NIST in July.

FOURIER-TRANSFORM ANALYTICAL MICROWAVE SPECTROSCOPY: A NEW TOOL FOR ANALYTICAL CHEMISTS

NIST has developed a new spectroscopic instrument for chemical analysis of gaseous molecules, which has both high sensitivity and 100 % species selectivity. The instrument is based on Fourier-transform microwave spectroscopy, a technique initially developed by spectroscopists for the investigation of molecular clusters and highly reactive molecules. The technique operates by collecting the coherent microwave emission from a sample of molecules excited by a pulse of microwave radiation. Measurement of the emission

frequency gives the identity of the molecular species while the amplitude of the emission signal gives the concentration of the species. Detection levels for molecules approach the 1×10^{-9} level. The sampling time is approximately 0.1 s, and the process is completely automated. Potential applications for this technology include monitoring industrial and automobile emissions, optimizing chemical manufacturing processes, and analyzing anesthetic levels in hospital environments. The response from the analytical community has been overwhelmingly positive. Plans to produce and market the instrument are being pursued. A provisional patent has been received on the instrument.

WORKSHOP ON QUALITY DOCUMENTATION FOR MEDICAL X-RAY CALIBRATION LABORATORIES

On April 3, 1996 NIST and the Council on Ionizing Radiation Measurements and Standards' (CIRMS) Medical Subcommittee held a workshop to promote the harmonization of quality documentation for medical x-ray calibration laboratories. A number of organizations in the United States are accrediting calibration laboratories to calibrate radiation detection instruments used for diagnostic x-rays. These include the National Voluntary Laboratory Accreditation Program (NVLAP), the American Association of Physicists in Medicine (AAPM) and the Conference of Radiation Control Program Directors. These organizations have many elements in common: they all function with approved operating procedures, they all trace their primary standards for radiation quantities to NIST, and they all require some degree of quality documentation. With the present world-wide emphasis on ISO9000 and quality documentation, the CIRMS' Medical Subcommittee serves as a forum for discussions of radiation measurement issues among these different groups. This workshop, which was held at NIST, provided an opportunity for a number of organizations and calibration laboratories to present their approaches to implementing ISO Guide 25 and ANSI Z540, which list the general requirements of calibration laboratories. A presentation was given on the NVLAP process and the status of their accreditation of laboratories for medical x-ray instrument calibrations. Representatives from the AAPM-accredited laboratories, K&S Associates in Nashville, the University of Wisconsin in Madison, and from the NVLAP-accredited Center for Devices and Radiological Health of the FDA outlined the quality manuals they have developed to meet ISO Guide 25. Harmonization of these laboratories is particularly important for mammography x-ray beam calibrations because the Mammography Quality Standards Act is forcing these

laboratories to demonstrate that they are meeting quality documentation requirements.

SLIT JET DISCHARGES: A NOVEL, INTENSE SOURCE OF SUPERSONICALLY COOLED RADICALS AND MOLECULAR IONS

The irony of chemical kinetics is that the most reactive species (i.e., radicals and molecular ions) are often present in the lowest concentrations, which makes them hard to isolate for detailed spectroscopic study. Furthermore, conventional electrical discharge techniques to prepare these species typically lead to characteristically high rotational and vibrational temperatures, creating a complicated environment for spectroscopic investigation. There have been many efforts to lower these temperatures by combining corona discharges with pinhole supersonic expansions, but the resulting densities drop off quadratically with distance from the nozzle. A NIST scientist recently developed a novel discharge source based on a pulsed slit supersonic expansion geometry, which yields high radical densities, low temperatures (20 K), sub-Doppler spectral linewidths, and 100 cm path lengths ideal for direct absorption spectroscopic applications.

The method utilizes a pulsed negative voltage applied to two insulated metal jaws which define the slit expansion orifice. When synchronized with the gas, this pulse strikes a smooth discharge with respect to the grounded valve body, causing electrons to flow upstream in the expansion. The net result is a discharge current wholly contained within the $300 \mu\text{m} \times 4 \text{ cm}$ region upstream of the slit and, therefore, transient species cooled effectively to supersonic jet temperatures. This slit discharge device has proved to be a rich source of jet cooled radicals and molecular ions. This work promises to permit detailed spectroscopic study of radicals and ions under low temperature conditions where the spectral analysis is far less congested. Such results are likely to be of interest for developing detailed, in situ plasma diagnostics for control and manipulation of chemical vapor deposition efficiencies in semiconductor chip fabrication.

OPTICAL DETECTION OF DEFECTS IN WIDE-BANDGAP SEMICONDUCTOR FILMS

Wide-bandgap Group-III nitride semiconductors are expected to become the basis for a new generation of solid-state light emitters and detectors, enabling applications such as high-density optical data storage, compact full-color displays, and solar-blind photodetectors. Because of the difficulty of growing large single crystals, these materials are usually grown in thin-film

form on single-crystal sapphire or silicon carbide substrates. The differences in lattice constants, thermal expansion, and chemical bonding between films and substrates result in large numbers of defects that degrade the performance of devices made from the films.

Researchers, in collaboration with the Johns Hopkins Applied Physics Laboratory, have shown that cathodoluminescence scanning electron microscopy (CL-SEM) can detect defects not observed by conventional scanning electron microscopy or optical microscopy. The CL-SEM technique reveals both defect microstructure and electronic energy levels. CL-SEM has provided significant new information about defects in a set of aluminum gallium nitride films grown by metal-organic chemical vapor deposition on sapphire. One type of defect observed by CL-SEM looks like a network of bright lines with threefold crystallographic symmetry. The lines are attributed to microcracks formed because of thermal expansion mismatch between the film and substrate. A second type of defect looks like a hexagonal region with a bright outline. The hexagonal defects are attributed to dislocation loops that may originate in the substrate and propagate into the film. Both types of defects produce energy shifts in the band-edge emission spectrum, which may arise from localized strains or compositional variation. Further work is planned to examine the effect of impurity doping and other growth parameters on the defects and to try to correlate these observations with other techniques such as x-ray diffraction imaging.

INDUSTRIAL COLLABORATION SHOWS POTENTIAL OF NEW MEASUREMENT METHOD

A collaboration between NIST and a private company has yielded new data on the molecular architecture of NIST SRM 1487, a poly(methylmethacrylate) relative molecular mass (M_r) standard. SRM 1487 was certified originally by ultracentrifugation, a method that yields only an average of the molecular mass distribution. Measurements made on a matrix assisted laser desorption ionization mass spectrometer (MALDI-MS) at the company were able to determine the mass number and quantity of each molecular species in the polymer. This M_r distribution is of particular interest to industry since it is the molecular characteristic that most affects the processing properties of a polymer. Current industrial practice is to characterize M_r distribution by size exclusion chromatography (SEC), which must be calibrated by M_r standards. The new information would make this SRM more useful as a calibration standard for SEC.

The collaborative study also provided details of the polymer structure specific to the polymerization chemistry. Analysis of the mass spectrogram showed that the polymer molecules were initiated from several different precursors that apparently governed the ultimate size of the polymer molecules. Such information could be used by producers of polymers to control more precisely the molecular architecture of polymers.

Although the use of MALDI-MS to determine M_r and M_w distributions of synthetic polymer SRM's appears promising, several fundamental challenges remain to be addressed. For example, comparisons of the mass spectrogram of the SRM 1487 with the size exclusion chromatogram of the same material show differences that must be resolved.

NIST has begun an expanded effort to evaluate MALDI-MS as a method of producing new SRMs certified for M_r distribution.

NEW REPORT ADDRESSES INDUSTRIAL RESEARCH NEEDS IN ELECTRONIC MATERIALS

In conjunction with the Electronic Materials Working Group (EMWG) of the President's National Science and Technology Council (NSTC), NIST has published a new report entitled *Beyond the Technology Roadmaps: An Assessment of Electronic Materials Research & Development*. This document, NISTIR 5777, was prepared in recognition of the critical importance of materials to the U.S. electronics industry and provides an assessment of electronic materials research and development issues and needs in the context of U.S. national competitiveness.

The report draws heavily on the findings and recommendations from the December 1994 industry-government-university Workshop on Electronic Materials. That workshop focused on materials issues and needs for five market segments: microelectronics, radio frequency and microwave electronics, photonics, mass storage, and module interconnection. From this workshop, five primary conclusions emerged:

- There is a continuing research challenge across the microelectronics industry to maintain the trend toward increased materials complexity and reduced device feature size.
- The microelectronics research community in the United States has undergone profound changes in the last 5 to 10 years as major industrial laboratories have reduced their support for advanced research and limited their efforts to solving more near term problems.

- The guidance that close coupling between researchers and manufacturers provided may in the future be largely provided by industry-wide technology road mapping led by key industrial associations.
- To support the continuing push toward increased material complexity and reduced device feature size, the U.S. Government should work to create an environment that encourages electronics companies to increase their participation in electronic materials research and development.
- Long-term goals should be focused on structuring the traditional industry, university, and federal lab materials research community to assure effective coordination of research to meet the future needs of the electronics industry.

A SILVER-BASED SUBSTITUTE FOR MERCURY CONTAINING DENTAL AMALGAMS

The development of a mercury-free metallic alternative to conventional dental amalgams has been the subject of a 2-year program supported by the National Institute of Dental Research (NIDR). The search for a metallic substitute to the amalgams has to begin with the problem of the consolidation of an easily deformable very plastic material into a strong solid, under the strict temperature, pressure, and time limitation imposed by common dental practice.

A metallic mercury free restorative material currently being developed at NIST is based essentially on metallic silver and displays relatively high values of ductility and flexural strength, but hardness and compressive strength are lower than those of amalgams. Cohesion in the new silver compacts results from a cold welding process, which occurs only between atomically clean metal surfaces. Silver powder cold welds adequately only after exposure to a mild acid, e.g., 1 % to 10 % fluoroboric acid. Silver formed by precipitation from an aqueous solution is most suitable for hand consolidation, being soft and ductile, with a particle size on the order of 0.2 μm to 2 μm and an irregular morphology.

Flexural strength is a mechanical parameter determined with relative ease and is representative of the mechanical strength of powder compacts. The observed values of the silver compacts, consolidated by hand using the tools and procedures normally employed by dentists, fall in the 80 MPa to 140 MPa range as compared, for example, to 115 MPa measured for a DispersalloyTM amalgam. Densities as high as 78 % of the theoretical density of silver can be achieved with consolidation pressures of 35 MPa to 50 MPa.

The silver-based compacts have the potential to meet the performance requirements of the industrial and marketing partners. Being mercury free, they provide an alternative in an anticipated situation where for environmental or other reasons, the use of mercury containing amalgam restoratives will be curtailed.

RECORD SETTING VALUES IN GIANT MAGNETORESISTANCE SPIN VALVES

In the few years since they were discovered, giant magnetoresistance (GMR) spin valves have become a hot topic in the computer industry. These ultrathin magnetic multilayer films are being developed by hard-disk-drive manufacturers as magnetic read-heads with unprecedented sensitivity for reading ultrahigh-density disks. Another potential application for GMR spin valves is magnetoresistive random access memory (MRAM) chips, which may become a nonvolatile replacement for DRAMs.

Recent investigations at NIST have concentrated on improving the GMR in spin valve films by optimizing the variables involved in the production and processing of the films. In recent months, this work has resulted in the largest GMR values ever reported for the three basic types of spin valves: 23.4 % for symmetric spin valves, 17 % for bottom spin valves, and 11.5 % in top spin valves. These NIST accomplishments constitute an important step toward the realization of GMR read-heads and MRAM chips.

WETTING OF POLYMER BRUSHES

Polymer "brushes," consisting of polymer chains so densely grafted to a substrate that they are strongly stretched away from the surface, are model systems for a wide class of surface modifying treatments and compatibilizers in technological applications. For instance, the ability to change the wettability of a surface can be changed dramatically by grafting on a thin polymer film. Recent neutron reflectivity measurements by scientists from NIST in collaboration with a private company have revealed some surprising behavior when these brush systems are in contact with a mixture of solvents. A miscible mixture of two solvents, one which prefers the polymer brush and another which instead prefers the substrate to which the brush is grafted, produces unusual wetting behavior due to the structure at the surface and the competition between the two solvents to wet different parts of the surface. For example, the polymer brushes stretch more in the presence of a better quality solvent, but in the solvent mixtures the addition of a small amount of a poor solvent produced, not collapse, but even stronger stretching of the brush.

LIMITED WATER SUPPLY FIRE SUPPRESSION TECHNOLOGIES

On March 12, 1996 a demonstration of limited water supply fire suppression technologies was hosted by NIST. This demonstration, sponsored by the United States Fire Administration, presented an overview of current research in low flow fire sprinkler system and residential water mist system technologies.

Attendees of the demonstration heard speakers from NIST, and other groups summarizing their research activities in the area of limited water supply fire suppression systems. In the afternoon, three full-scale fire demonstrations were conducted in the Large Fire Research Facility. Each demonstration utilized a typical living room arrangement with carpeting, wood paneling, sofa, love seat, and drapes. The fires were started by lighting a book of matches on the sofa.

Two fire suppression systems were demonstrated. One of the systems was a prototype limited area dwelling sprinkler system, as described in NFPA's National Fire Codes NFPA 13D Chapter 5. The other system was a prototype water mist system, which will be considered by the new NFPA 750 standard on water mist fire suppression systems. Both suppression systems successfully controlled the fire and maintained tenable conditions in the room during their operation.

The last demonstration of the day did not have an installed fire suppression system. Two minutes after ignition, conditions in the living room became untenable, with "flash over" occurring soon afterward. Over 450 000 fires occur annually in residential properties, resulting in approximately 4000 civilian fire deaths. The prototype residential fire protection systems show promise for increasing life safety in homes.

NIST ESTIMATES NATIONWIDE ENERGY IMPACT OF AIR LEAKAGE IN U.S. OFFICE BUILDINGS

NIST has conducted a study in which the energy consumption due to air leakage in U.S. office buildings was estimated. The results of this study show that air leakage accounts for roughly 15 % of the heating load in office buildings nationwide, with a higher percentage in recently constructed buildings. The impact on cooling loads is only 1 % or 2 %. In terms of primary energy, air leakage may, therefore, account for as much as 0.4 EJ (about one-half quad) in all U.S. commercial buildings. Previous work at NIST has demonstrated that office buildings are much leakier than was generally assumed, with potential negative impacts on energy consumption, indoor air quality, and the durability of building materials. To estimate the energy impacts of this air leakage, this preliminary analysis was performed on a set of

25 buildings that represent the U.S. office building stock as of 1995. The energy impact of air leakage in each building was estimated by performing an hourly analysis over 1 year for each building and then summing the results weighted by the floor area represented by the buildings. Future work will include refinement of this estimate and the study of approaches to reducing this energy penalty in new and existing buildings through the construction of tighter building envelopes and better control of ventilation systems.

NIST STARTS STUDY OF RESIDENTIAL CARBON MONOXIDE DETECTORS

NIST recently began a study of residential carbon monoxide (CO) detectors for the National Fire Protection Association (NFPA) Research Foundation. This study will focus on the distribution of CO in residential buildings as it relates to the installation of CO detectors. The study is being conducted to address such issues as how many CO detectors should be installed in homes and where they should be installed to warn building occupants of atypical CO concentrations from, for example, furnace venting failures and attached garages. The study will be conducted in two phases, with the first phase being a literature review of the technical issues related to CO detection in homes including residential CO sources, air movement and contaminant distribution in single-family residential buildings, and air and contaminant mixing in buildings. The information obtained in the literature review will be analyzed to determine what is known and what research is needed to support the development of guidance on CO detector installation. In the second phase of the effort, an experimental plan will be developed for field measurements and computer modeling to obtain the technical information necessary to make sound recommendations on the installation of CO detectors in homes. The project is being overseen by an NFPA Research Foundation Technical Advisory Committee (TAC) consisting of detector manufacturers, organizations representing fire officials and building code officials, and the Consumer Product Safety Commission.

NIST CONDUCTS COMPUTER ANALYSIS TO ANALYZE MOISTURE CONTROL PRACTICES IN MANUFACTURED HOUSING

NIST recently conducted a study for the Department of Housing and Urban Development (HUD) to quantify the effectiveness of roof cavity moisture control practices in manufactured houses. HUD publishes standards that regulate the construction of manufactured houses sold in the United States. These standards require that the roof

cavity have a prescribed amount of either passive or mechanical ventilation. The study was conducted using MOIST, a NIST-developed computer program that predicts moisture content of building materials for various climates and construction types.

The analysis revealed that manufactured homes constructed in compliance with the passive attic ventilation requirements always had roof sheathing moisture content within acceptable levels below fiber saturation. However, the specified mechanical ventilation rate was found to be too low resulting in a roof sheathing moisture content that approached fiber saturation. In addition, the use of a ceiling vapor retarder in a hot and humid climate was found to lead to high surface relative humidity at the upper surface of the vapor retarder. This study recommended that considerably higher mechanical ventilation rates are needed to prevent moisture problems in roof cavities in cold climates. Furthermore, a separate set of practices are needed to prevent moisture problems in hot and humid climates.

NIST PUBLISHES GUIDELINES FOR EVALUATING ELECTRONIC DATA INTERCHANGE (EDI) PRODUCTS

NIST Special Publication 500-231, Guidelines for the Evaluation of Electronic Data Interchange Products, assists users in determining which product, among many candidate products, best meets the user's requirements. As with most software products, EDI products vary greatly. Products offer a host of options such as communications functions, forms generation, and data entry capabilities, among others. The publication presents an EDI tutorial and discusses the functionality of EDI products, performance issues, and the integration of EDI products into the business process.

NEW PUBLICATION FOCUSES ON C++ IN SAFETY CRITICAL SYSTEMS

NISTIR 5769, C++ in Safety Critical Systems, provides an assessment of how well C++ fits into recent software guidelines for safety critical systems and presents a collection of techniques and idioms for constructing safer C++ code. The safety of software is influenced by the choice of implementation language and the choice of programming idioms. C++ is gaining popularity as the implementation language of choice for large software projects because of its promise to reduce the complexity and cost of their construction.

DATA COMMUNICATIONS STRATEGY DOCUMENT FOCUSES ON NETWORKING TECHNOLOGIES AND INTEROPERABILITY ISSUES

NISTIR 5793, Data Communications Strategy, provides organizations with information that needs to be considered when acquiring computer networking technology products and services. The document surveys the services currently provided by nonproprietary communications technology, compares and contrasts services, and assesses the degree to which the major protocols or protocol suites have gained or are expected to gain marketplace acceptance.

Standard Reference Materials

A NEW SRM DEVELOPED IN PED

A standard reference material for optical fiber ferrule hole diameter has been developed with assistance from the optical fiber industry. SRM 2522, Pin Gage Standard for Optical Fiber Ferrules, consists of a steel wire of diameter 126 μm selected for outstanding roundness and straightness dimensional characteristics. SRM 2522 will be used by manufacturers of optical fibers and ferrule connectors as master reference standards or instrument setting artifacts to standardize the calibration and measurement of pin gages used in optical fiber ferrule manufacturing.

The most recent version of the NIST-developed high-accuracy micrometer for diameter measurements was used to verify and calibrate SRM 2522 artifacts. The unique difficulties associated with the measurement of these very small diameter artifacts have been solved with this measurement process and results in unparalleled accuracy for small diameter artifact calibrations. This process allows the measurement uncertainties for these artifacts to approach 35 nm, the lowest levels ever reported for diameter measurements at NIST.

NEW SRM IS HEAVY DUTY FOR MEASURING FATS

More and more health-conscious consumers are using the fat content listing on food labels as a guide for their dietary choices. To ensure that this labeling is accurate, NIST has collaborated with the U.S. Department of Agriculture (USDA) to prepare a Standard Reference

Material for laboratories measuring fatty acids and cholesterol in food. The SRM provides a means for these labs to verify the exactness of their measurements and methods. The SRM consists of four 15 g bottles of frozen blended foods typically consumed in the United States. The blended food was supplied through a multicenter clinical study by the National Heart, Lung and Blood Institute of the National Institutes of Health. The USDA's Food Composition Laboratory prepared the food slurry, which includes fruit juices, breakfast cereals, meats, vegetables and breads. NIST chemists then certified the concentration of cholesterol, and six of the most abundant fatty acids, in the slurry. The new SRM also provided data for proximates, including protein, moisture, total fat, ash, carbohydrate and calories. SRM 1544 is available for \$179 from the NIST Standard Reference Materials Program, 204 Engineering Mechanics Building, Gaithersburg, MD 20899-0001, (301) 975-6776, fax: (301) 948-3730, e-mail: srminfo@enh.nist.gov.

database are from a widely known monograph, *Vibrational and Electronic Energy Levels of Polyatomic Transient Molecules*, by a NIST molecular physicist. The expanded VEEL database is available for \$250 from the Standard Reference Data Program, Building 820, Rm. 113, NIST, Gaithersburg, MD 20899-0001, (301) 975-2208, fax: (301) 926-0416; e-mail: srdata@enh.nist.gov. Owners of a previous edition may update for \$50.

Standard Reference Data

TRANSIENT MOLECULES DATABASE EXPANDED

A major resource for physical scientists, environmental researchers, combustion engineers and others in science and industry seeking a better understanding of various chemical processes has been expanded and now includes spectroscopic information on 1796 short-lived molecules. This is an increase of more than 200 molecules from the previous version. The NIST Vibrational and Electronic Energy Levels of Small Polyatomic Transient Molecules Database (or VEEL), Version 4.0, Standard Reference Database 26, is now available. The computer program consists of two molecular databases and the associated reference files. It is designed to provide rapid access to all published experimental data on the ground-state vibrational fundamentals of transient molecules having from 3 atoms to 16 atoms, the electronic energy levels of excited-state vibrational fundamentals of transient molecules having from 3 atoms to 6 atoms, and of selected transient molecules having from 7 atoms to 16 atoms. Literature references in the

Calendar

July 22–25, 1996

SIXTH INTERNATIONAL MEETING ON CHEMICAL SENSORS

Location: National Institute of
Standards and Technology
Gaithersburg, MD

Purpose: This conference will provide a forum for active discussion about the future of chemical sensors. The diversity of techniques applied to chemical sensing requires input from engineers, biologists, chemists, material scientists, and mathematicians if they are to reach their full, predicted potential. The interdisciplinary nature of the conference provides a unique opportunity to gather researchers from diverse disciplines together in a single location to focus on a single topic.

Topics: Sensing principles and mechanisms, new sensor materials development, novel approaches to sensing, ion selective electrodes, electrochemical devices, optical devices, acoustic-wave devices, pattern recognition methods, gas sensors, humidity sensors, biosensors, process control, medical diagnostics, environmental applications, sensor fabrication technology, and sensor signal processing.

Format: Plenary presentation, and oral and poster presentations of contributed papers.

Audience: This conference is designed to facilitate the exchange of information among an international group of scientists and engineers.

Sponsor: NIST.

Contact: Howard Weetall, NIST, A353 Chemistry Building, Gaithersburg, MD 20899-0001, 301/975-2628, email: weetall@micf.nist.gov.

August 5–7, 1996

THE NEUTRON SCATTERING SATELLITE MEETING TO THE XVII IUCr CONGRESS

Location: National Institute of
Standards and Technology
Gaithersburg, MD

Purpose: To address advances in neutron scattering instrumentation and applications to crystallography,

materials science, and molecular biology, including reflectometry, small-angle scattering, and inelastic scattering.

Topics: Development in neutron instrumentation and detecting advances in data analysis techniques; recent applications to crystallography, materials science, thin films, and molecular biology; neutron sources.

Format: Oral presentations and posters.

Audience: Researchers in neutron scattering.

Sponsors: NIST, International Union of Crystallography.

Contact: Susan Krueger, NIST, E151 Reactor Building, Gaithersburg, MD 20899-0001, 301/975-6734, email: krueger@enh.nist.gov.

October 7–9, 1996

ANNUAL SYMPOSIUM ON OPTICAL MATERIALS FOR HIGH POWER LASERS

Location: National Institute of
Standards and Technology
Boulder, CO

Purpose: To exchange information on the technology and physics of materials for high-energy/high-power lasers.

Topics: New materials; bulk, surface, and thin-film damage phenomena and levels; preparation of optical materials (bulk, surfaces, and thin films); measurements of properties (optical, non-linear optical, thermal, and mechanical) of materials (bulk, surfaces, and thin films) important to the damage process; design and degradation considerations for high output systems; damage threshold measurement experimental design; data reduction and standards of laser-induced damage; fundamentals and modeling of laser interaction with optical materials.

Format: Symposium, both poster and oral, no parallel sessions. (Internal mini-symposium: Laser-Induced Damage in Optical Fibers, chaired by Robert E. Setchell, Sandia National Laboratories) Abstracts: 150 words due by July 15, 1996.

Audience: Industry, government agencies, and academia.

Sponsors: Lawrence Livermore National Laboratory and Sandia National Laboratory. Cooperating Organizations: NIST, Center for Research and Education in Optics and Lasers, Los Alamos National Laboratory, Bennett Optical Research, and SPIE-The International Society for Optical Engineering.

Contact: Donna Wilson or M.J. Soileau, c/o CREOL, University of Central Florida, P.O. Box 162700, 4000 Central Florida Blvd., Orlando, FL 32816-2700, 407/823-6834, fax: 407/823-6966, email: donna@creol.ucf.edu/mj@creol.ucf.edu

October 15–17, 1996

**SIXTH INTERNATIONAL WORKSHOP ON
MOISTURE MEASUREMENT AND CONTROL
FOR MICROELECTRONICS**

Location: National Institute of
Standards and Technology
Gaithersburg, MD

Purpose: Exchange of information, ideas, problems, and solutions in a technology concern that underlies many of the industry-stated priorities contained in the national technology roadmaps for semiconductors and electronic interconnects.

Topics: Moisture effects on polymer packaging and substrate materials; moisture-related device- and board-level performance, failure, and reliability; impact of moisture on semiconductor manufacturing; impact of moisture on board-level manufacture and assembly; statistical process control and moisture; moisture measurement techniques; modeling of moisture effects; hermeticity; moisture concerns in modern hermetic and nonhermetic packaging schemes; military and aerospace moisture requirements.

Format: General session.

Audience: Leading practitioners and authorities from industry, academia, and government.

Sponsors: NIST, Rome Laboratories.

Contact: Michael Schen, NIST, B320 Polymer Building, Gaithersburg, MD 20899-0001, 301/975-6741, email: schen@micf.nist.gov.

October 22–25, 1996

**19th NATIONAL INFORMATION SYSTEMS
SECURITY CONFERENCE**

Location: Baltimore Convention Center
Baltimore, MD

Purpose: To focus on the theme of Policy and Technology: Partners in Solutions.

Topics: Intrusion detection, WWW security, incident response, research and development for secure products, risk management, system integration, privacy, disaster recovery and business continuity, computer crime, ethics, and new security paradigms.

Format: Tutorials, exhibits, and two evening functions for additional networking.

Audience: The audience represents a broad range of information security interests spanning government, industry, commercial, and academic communities.

Sponsors: NIST, National Computer Security Center.

Contact: Tim Grance, 426 Building 820, Gaithersburg, MD 20899-0001, 301/975-4242, fax: 301/948-0279, email: tim.grance@nist.gov.

November 12–14, 1996

**FOURTH ANNUAL MEETING OF THE
COUNCIL ON IONIZING RADIATION
MEASUREMENTS AND STANDARDS
(CIRMS)**

Location: National Institute of
Standards and Technology
Gaithersburg, MD

Purpose: To advance and disseminate the physical measurements and standards needed for safe and effective technological application of ionizing radiation.

Topics: Medical applications, public/environmental radiation protection, occupational radiation protection, radiation effects.

Format: General session.

Audience: Representatives from academia, professional and industrial organizations; governmental department and agencies; and interested individuals involved in nearly every aspect of ionizing radiation.

Sponsor: NIST.

Contact: Bert Coursey, NIST, C229 Radiation Physics Building, Gaithersburg, MD 20899-0001, 301/975-5584, email: coursey@micf.nist.gov.

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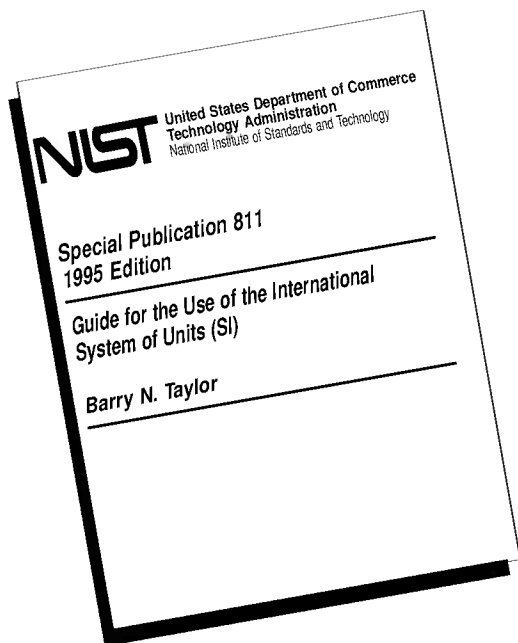
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The International System of Units (SI)

The Modern Metric System



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The 1995 edition of the National Institute of Standards and Technology Special Publication 811, *Guide for the Use of the International System of Units (SI)*, by Barry N. Taylor, is now available.

The 1995 edition of SP 811 corrects a number of misprints in the 1991 edition, incorporates a significant amount of additional material intended to answer frequently asked questions concerning the SI and SI usage, and updates the bibliography. The added material includes a check list for reviewing the consistency of written documents with the SI. Some changes in format have also been made in an attempt to improve the ease of use of SP 811.

The topics covered by SP 811 include:

- NIST policy on the use of the SI in NIST publications.
- Classes of SI units, those SI derived units that have special names and symbols, and the SI prefixes that are used to form decimal multiples and submultiples of SI units.
- Those units outside the SI that may be used with the SI and those that may not.
- Rules and style conventions for printing and using quantity symbols, unit symbols, and prefix symbols, and for spelling unit names.
- Rules and style conventions for expressing the results of measurements and the values of quantities.
- Definitions of the SI base units.
- Conversion factors for converting values of quantities expressed in units that are mainly unacceptable for use with the SI to values expressed mainly in units of the SI.
- Rounding numbers and rounding converted numerical values of quantities.

Single copies of the 84-page SP 811 may be obtained from the NIST Calibration Program, Building 820, Room 232, Gaithersburg, MD 20899-0001, telephone: 301-975-2002, fax: 301-948-3825.

NIST Technical Publications

Periodical

Journal of Research of the National Institute of Standards and Technology—Reports NIST research and development in those disciplines of the physical and engineering sciences in which the Institute is active. These include physics, chemistry, engineering, mathematics, and computer sciences. Papers cover a broad range of subjects, with major emphasis on measurement methodology and the basic technology underlying standardization. Also included from time to time are survey articles on topics closely related to the Institute's technical and scientific programs. Issued six times a year.

Nonperiodicals

Monographs—Major contributions to the technical literature on various subjects related to the Institute's scientific and technical activities.

Handbooks—Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

Special Publications—Include proceedings of conferences sponsored by NIST, NIST annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

National Standard Reference Data Series—Provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NIST under the authority of the National Standard Data Act (Public Law 90-396). NOTE: The Journal of Physical and Chemical Reference Data (JPCRD) is published bimonthly for NIST by the American Chemical Society (ACS) and the American Institute of Physics (AIP). Subscriptions, reprints, and supplements are available from ACS, 1155 Sixteenth St., NW, Washington, DC 20056.

Building Science Series—Disseminates technical information developed at the Institute on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

Technical Notes—Studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NIST under the sponsorship of other government agencies.

Voluntary Product Standards—Developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The standards establish nationally recognized requirements for products, and provide all concerned interests with a basis for common understanding of the characteristics of the products. NIST administers this program in support of the efforts of private-sector standardizing organizations.

Order the following NIST publications—FIPS and NISTIRs—from the National Technical Information Service, Springfield, VA 22161.

Federal Information Processing Standards Publications (FIPS PUB)—Publications in this series collectively constitute the Federal Information Processing Standards Register. The Register serves as the official source of information in the Federal Government regarding standards issued by NIST pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations).

NIST Interagency Reports (NISTIR)—A special series of interim or final reports on work performed by NIST for outside sponsors (both government and nongovernment). In general, initial distribution is handled by the sponsor; public distribution is by the National Technical Information Service, Springfield, VA 22161, in paper copy or microfiche form.

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